Executive Summary

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Introduction

Lawrence Livermore National Laboratory (LLNL), a U.S. Department of Energy (DOE) facility operated by the University of California, serves as a national resource of scientific, technical, and engineering capabilities. The Laboratory's mission focuses on nuclear weapons and national security, and over the years has been broadened to include areas such as strategic defense, energy, the environment, biomedicine, technology transfer, the economy, and education. The Laboratory carries out this mission in compliance with local, state, and federal environmental regulatory requirements. It does so with the support of the Environmental Protection Department, which is responsible for environmental monitoring and analysis, hazardous waste management, environmental restoration, and assisting Laboratory organizations in ensuring compliance with environmental laws and regulations.

LLNL comprises two sites: the Livermore site and Site 300. The Livermore site occupies an area of 3.28 square kilometers on the eastern edge of Livermore, California. Site 300, LLNL's experimental testing site, is located 24 kilometers to the east in the Altamont Hills, and occupies an area of 30.3 square kilometers. Environmental monitoring activities are conducted at both sites as well as in surrounding areas.

This summary provides an overview of LLNL's environmental activities in 1996, including radiological and nonradiological surveillance, effluent and compliance monitoring, remediation, assessment of radiological releases and doses, and determination of the impact of LLNL operations on the environment and public health.

Environmental Monitoring Results

During 1996, the Environmental Protection Department sampled air, sewerable water, ground water, surface water, soil and sediment, vegetation and foodstuffs, and measured environmental radiation. Over 20,300 environmental samples were taken and analyses were conducted for more than 310,000 analytes. These numbers represent increases of 9% and 25%, respectively, over the previous year.

LLNL's sampling networks undergo constant evaluation; changes are made, as necessary, to ensure adequate, cost effective monitoring of all environmental media potentially affected by LLNL operations. Once samples are collected, they are analyzed for radioactive and nonradioactive substances using standard methods such as analytical procedures approved by the U.S. Environmental Protection Agency (EPA), special systems such as the continuous monitoring system for Livermore site sewage, or special analytical techniques designed to measure very low levels of radionuclides. Environmental radiation is also measured directly using dosimeters.

Air Monitoring

Air surveillance monitoring was performed for various airborne radionuclides (including particles and tritiated water vapor) and beryllium at locations on the Livermore site, Site 300, throughout the Livermore Valley, and in Tracy. Concentrations of all monitored radionuclides and beryllium at all of these locations were well below levels that would endanger the environment or public health, according to existing regulatory standards. As examples: the concentration of plutonium on air filter samples collected at LLNL on-site locations, perimeter locations, and Livermore Valley locations showed median values, respectively, of only 0.02%, 0.02%, and 0.002% of the federal Derived Concentration Guide (DCG), which specifies the concentration of radionuclides that could be inhaled continuously 365 days a year without exceeding the DOE radiation protection standard for the public. Median concentrations of tritiated water vapor at Livermore Valley sampling locations showed a highest median value of 0.001% of the DCG, while the highest median values on the Livermore site perimeter and within the site boundaries were, respectively, 0.007% and 0.2% of the DCG. The highest median concentration of beryllium on the Livermore site perimeter was 0.1% of the guideline level established by the Bay Area Air Quality Management District and the EPA. Similar results (small fractions of guideline levels) were found at air surveillance monitoring locations at Site 300 and its environs.

Stack Effluent Monitoring

Stack air effluent was monitored continuously at nine buildings on the Livermore site. These included the Tritium Facility (Building 331), the Plutonium Facility (Building 332), the Heavy Element Facility (Building 251), and four buildings involved with Laser Isotope Separation program activities. This directly measured data on source emissions provides an accurate, time resolved measure of the quantity of radionuclides released from these major facilities, and provides realistic source terms to improve the quality and credibility of our air dispersion and dose assessment modeling.

Wastewater Monitoring

Discharges of radioactive and hazardous materials to the combined sanitary and industrial sewer at the Livermore site are controlled by limiting the disposal of those materials, implementing engineering controls, and routing some discharged material to retention tanks for later characterization and treatment. Flow-proportional samples of discharged wastewater are regularly collected and analyzed to assure that LLNL's sewage effluent meets the requirements of the permit granted by the City of Livermore. In addition, effluent is monitored continuously for pH, selected metals, and radioactivity. Should concentrations be detected above warning levels, LLNL's sewer diversion system is automatically activated. The diversion system captures all but the first few minutes of wastewater flow that causes an alarm, thereby protecting the Livermore Water Reclamation Plant (LWRP) and minimizing any required cleanup.

In 1996, the Livermore site discharged an average of 0.94 million liters per day of wastewater to the City of Livermore sewer system, an amount that constitutes 4.6% of the total flow to the system (about 20% of this flow was generated by Sandia National Laboratory/California). LLNL achieved greater than 99% compliance with LWRP permit limits covering discharges into the sanitary sewer during the year. One daily analytical result for mercury exceeded the discharge limit in LLNL's Wastewater Discharge Permit, but was not considered a permit violation because it fell within the range of uncertainty in the effluent pollutant level. Concentrations of other metals in LLNL's sewer effluent were below discharge limits. Seven pH excursions occurred in 1996 and were reported to the LWRP. Only one of the incidents warranted a sewage diversion, and the diverted wastewater was released back to the sanitary sewer when analysis showed it was within acceptable limits. The LWRP issued two Letters of Concern for the pH excursions. However, in March 1997, LLNL was issued a notice of violation (NOV) for pH and silver exceedances occurring in February 1997. The NOV specifically targeted these two discharges, but treated the pH exceedance as a continuation of the 1996 pH exceedances. All pH incidents were short-duration, relatively small-volume discharges.

Water Monitoring

Surface water sampling and analysis are a large part of the LLNL surveillance and compliance monitoring effort for the Livermore site, Site 300, and their surrounding regions. The waters monitored include storm water runoff; rainfall; reservoirs and ponds, including the swimming pool and Drainage Retention Basin at the Livermore site; tap water; treated ground water discharges; wastewater discharges from cooling towers at Site 300; and drinking water supply wells. Depending on location, the samples may be analyzed for gross alpha and gross beta radiation, tritium, uranium, and nonradioactive pollutants, including solvents, metals, high explosives, and pesticides and other properties such as total suspended solids, conductivity, and pH.

In August 1996, EPA awarded LLNL the national first place award in the industrial category for its excellent storm water management program.

Ground water in the Livermore Valley and the Altamont Hills is monitored to assess the progress of remediation efforts in areas of known contamination, to test that LLNL operations do not significantly impact local water sources, and to comply with numerous federal, state, and local permits. Ground water samples are routinely measured for tritium, uranium, and other radioisotopes, gross radioactivity, toxic metals, a wide range of organic chemicals and other general contaminant indicators. Special consideration is given to monitoring those dissolved elements and organic compounds that are known to be toxic in trace amounts. In 1996 at the Livermore site, no ground water in monitored off-site wells exceeded primary drinking water maximum contaminant levels (MCLs) for any of the monitored constituents. At Site 300, tritiated water and depleted uranium have been released to ground water in the past, but boundaries of the contaminated water lie within the site boundaries, and this water is not used for agriculture nor consumed by people or cattle. Fate and transport modeling predicts the tritium will decay to activity levels below the drinking water MCL before site boundaries are reached, and maximum uranium activities that could reach potential exposure points are estimated to be small compared to the California MCL for uranium in drinking water. Trichloroethylene (TCE) has been released to ground water at numerous locations at Site 300 in the past. With the exception of a plume extending off site from the Eastern General Services Area, all of the TCE-bearing ground water is on site. Water in the off-site plume is being pumped back to the site and cleansed of TCE.

Soil and Sediment Monitoring

Soil and sediment sample analyses for the Livermore site in 1996 indicated that the impact of Laboratory operations on these media were insignificant and unchanged from previous years. The highest measured level of plutonium (isotopes 239 and 240) represented 6.5% of the EPA preliminary remediation goal for commercial or industrial sites; this occurred at the LWRP. At Site 300, the concentrations of radionuclides and beryllium in soil samples were representative of background or naturally occurring levels, as in previous years, with the exception of one sampling location. Elevated concentrations of uranium-238 and beryllium found at location 812N in 1996 were attributed to contamination by debris from firing table experiments.

Vegetation and Foodstuffs Monitoring

Area vegetation and foodstuffs are monitored for their tritium content. Tritium concentrations in samples taken near the Livermore site were found to be higher than those in samples taken from more distant locations, consistent with the trend of data over the last 15 years. The tritium concentrations in vegetation in 1996 were not

significantly different than those reported in 1995. In 1996, as in the past, tritium concentrations in Livermore Valley wines were slightly above those for wines tested from Europe and other locations in California; but the tritium levels are quite low. Mean levels for the 1996-sampling-year data from all areas were not significantly different from those reported for the 1994 and 1995 sampling years. Even the highest detected value, 5.6 becquerels per liter (152 picocuries per liter), represents only 0.8% of the amount of tritium California allows in drinking water (no health standards exist for radionuclides in wine).

Estimates of Releases Based on Monitoring and Inventory Data

The foregoing monitoring data, supplemented by radionuclide inventory data from LLNL's radioactive materials management areas, provide estimates of the total quantity and type of radionuclides released from the Laboratory during operations in 1996. The amount of radioactivity released from LLNL was slightly higher than in 1995, but was typical of levels over the last five years, and well below the those seen in 1991 and earlier years.

The most significant radiological effluent for the Livermore site continues to be tritium, the radioactive isotope of hydrogen. The source of nearly all tritium emissions is air emissions from Building 331, the Tritium Facility. Increased decontamination and decommissioning activities in this facility accounted for the higher emissions compared to the previous year. At Site 300, the dominant radioactive effluent is depleted uranium, which contains isotopes with atomic weights 238, 235, and 234 in the weight percentages 99.8, 0.2, and 0.0005, respectively. The primary sources of these emissions were experiments on the firing tables adjacent to Buildings 801 and 851, resulting in estimated releases of the three isotopes that were about 1.6-times higher than those in 1995, but within the range of variation seen from year to year due to changes in the level of operations at the firing tables. The impact of these releases on public health is summarized in the next section. Nonradioactive air emissions from exempt and permitted sources at LLNL are quite small; for example, total emission of nitrogen oxides from the Livermore site is 58 kg / day, which is 0.012% of the amount for the total Bay Area; corresponding numbers for reactive organics are 30 kg / day and 0.006%.

Radiological Dose Assessment

Radiological dose-assessment modeling, using EPA-mandated computer models, actual LLNL meteorology, population distributions appropriate to the two sites, and 1996 radionuclide inventory and monitoring data, was conducted this past year for each key facility and each new or modified emission point at the Livermore site and Site 300.

The public doses we report result from air releases of radionuclides during routine operations and (when applicable) from accidents. The principal exposure pathways are taken into account: internal exposures from inhalation of air and ingestion of foodstuffs and drinking water, and external exposures from contaminated ground and immersion in contaminated air. Releases of radioactivity from LLNL via the water pathway do not contribute to the public dose, since they are not consumed by any individual.

The calculated total potential dose for the sitewide maximally exposed individual (SW-MEI), i.e., a hypothetical member of the public having the greatest possible exposure from Livermore site operations in 1996, was 0.93 microsievert (0.093 millirem) for the Livermore site. This exceeds last year's value by 0.52 microsievert (0.052 millirem), primarily because of increased decontamination and decommissioning activity in the Tritium Facility. Trends in this dose over the last seven years are generally downward from the 2.40 microsievert (0.24 millirem) level in 1990; these are small radiation quantities, exhibiting large percentage fluctuations from one year to the next.

The calculated total potential dose to a hypothetical person having the greatest possible exposure at Site 300 during 1996 was 0.33 microsievert (0.033 millirem). Explosive tests at the Building 801 and Building 851 firing tables accounted for practically this entire amount. This total dose is about 43% larger than the previous year's value, reflecting the use of greater quantities of depleted uranium in the explosives experiments. Trends in annual dose levels from Site 300 operations show that this magnitude of year-to-year fluctuation is typical.

The doses to the maximally exposed public individual from Livermore site and Site 300 emissions, respectively, amounted to about 0.9% and 0.3% of the EPA National Emission Standards for Hazardous Air Pollutants (NESHAPs) standard. These doses are a small fraction (about 1/3000) of the doses received by these populations from natural background radiation. Thus, the potential radiological doses from LLNL operations in 1996 were well within regulatory limits and were very small compared to doses from natural background radiation sources.

Environmental Compliance and Program Activities

LLNL works to ensure that its operations comply with all environmental laws and federal, state, and local regulatory guidelines. Many activities related to water, air, waste, waste reduction, community "right to know," and other environmental issues were addressed in 1996.

Ground Water Remediation

Both the Livermore site and Site 300 are Superfund sites under the jurisdiction of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and are undergoing remedial activities. The primary treatment technology used at the Livermore site to remediate contaminated ground water is pump-and-treat technology. In 1996, nine treatment facilities at the Livermore site processed over 400 million liters of ground water, removing approximately 80 kilograms of volatile organic compounds (VOCs) plus smaller quantities of dissolved fuel hydrocarbons (FHCs). These efforts at control and remediation have stopped the off-site westward migration of VOC plumes from the Livermore site and have reduced plume size. The feasibility of using passive bioremediation in Treatment Facility F (TFF) was demonstrated to the satisfaction of regulating agencies in 1996. Significant progress also occurred at Site 300, where more than 15 kilograms of VOCs were removed from soil and ground water in four treatment areas. Since initiating cleanup, the extension of a VOC plume beyond Site 300 boundaries in the General Services Area, for example, has decreased from 1200 meters to 300 meters.

Waste Minimization and Pollution Prevention

In its annual review of waste minimization and pollution prevention activities, LLNL developed a new, weighted ranking system to prioritize and evaluate its waste streams. Rather than simply considering total waste volume as previously, the new criteria also consider cost, type of waste, and operational aspects. The 20 waste stream components having highest priority under the new system contrast sharply with the corresponding set under the old; transuranic and transuranic-mixed and low-level wastes now rank as highest priority for LLNL, even though their quantities are rather low.

The trend in routine waste generation at LLNL over the past seven years shows dramatic reductions in all four categories: radioactive, mixed, hazardous, and sanitary. Comparing 1996 to 1990 levels, these categories have undergone reductions of 77%, 89%, 81%, and 29%, respectively. The total waste diverted from landfills in 1996 was more than 20,000 tons, almost five times the total for the previous year; beneficial reuse of soil on site was responsible for this large increase. LLNL has reduced its nonhazardous solid waste stream by 30% since 1990. The Laboratory has been chosen to receive a National DOE P2 (pollution prevention) award for its achievements in solid waste recycling of construction and demolition debris.

Chemical inventories at LLNL are tracked through the use of bar codes, laser scanners, and customized software in an inventory system called ChemTrack. The 1996 inventory featured 185,000 chemical containers ranging from 210-liter drums to gram-quantity vials, and was the most accurate and efficient to date because of the addition of new

hand-held bar code scanners. ChemTrack minimizes the purchase of new chemicals, thereby reducing procurement costs and the generation of hazardous waste.

Air, Wastewater, and Water Compliance

LLNL continued to perform all activities necessary to comply with clean air and clean water requirements. In 1996, the Bay Area Air Quality Management District (BAAQMD) issued or renewed 194 permits to operate for the Livermore site. The San Joaquin Valley Unified Air Pollution Control District issued or renewed 43 permits for Site 300 operations. LLNL has permits for underground and aboveground storage tanks and for discharge of treated ground water, industrial and sanitary sewage, and storm water. Site 300 has additional permits for inactive landfills, cooling tower discharges, operation of the sewer lagoon, septic tanks, and leach fields. The Laboratory complies with all requirements for self-monitoring and inspections associated with these permits.

Environmental Occurrences

Notification of environmental occurrences at the Laboratory is required under a number of environmental laws, regulations, and DOE orders. LLNL responded to 14 incidents that required federal and/or state agency notification during 1996. None of these caused adverse impact to human health or the environment.

Endangered Species

LLNL must meet the requirements of both U.S. and California Endangered Species Acts. Examples of 1996 actions in this area concern the large-flowered fiddleneck (*Amsinckia grandiflora*), a federally listed endangered plant species, and the red-legged frog (*Rana aurora dragtonii*), the largest frog native to California and presently under the federal status "threatened." Two of the three known natural populations of *Amsinckia grandiflora* occur at Site 300, which has been designated as a critical habitat for the plant. In 1996, the number of fiddleneck plants at the site increased, owing to a reduction in exotic grass cover. Also at Site 300, two new populations of the red-legged frog were found at wetlands locations.

Conclusion

The current techniques used at the Laboratory for environmental monitoring are very sensitive, allowing detection at extremely low levels of constituents. The combination of surveillance and effluent monitoring, source characterization, and computer modeling show that radiological doses to the public caused by LLNL operations are less than 1.0% of regulatory standards and are about 3000 times smaller than the doses received from background radiation. The analytical results and evaluations generally show continuing

low contaminant levels, reflecting both decreased operations and the responsiveness of the Laboratory in controlling pollutants.

In 1996, significant achievements were made in environmental compliance activities related to water, air, waste, and waste reduction. National awards were received for LLNL's storm water management program and for achievements in solid waste recycling of construction and demolition debris. Ground water remediation activities have stopped the westward migration of plumes at the Livermore site; waste minimization efforts have significantly reduced the amount of waste generated in LLNL operations; recycling efforts have diminished the quantity of waste sent to landfills; and efforts at waste reduction and pollution prevention have capitalized on a variety of opportunities to reduce or eliminate, recover, or recycle potential pollutants.

In summary, the results of the 1996 environmental programs demonstrate that LLNL is committed to protecting the environment and ensuring that its operations are conducted in accordance with applicable federal, state, and local laws and regulations. The environmental impacts of LLNL operations are minimal and pose no threat to the public or the environment.